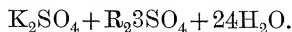leading member of which beryllium unquestionably is, stands certainly in the nearest proximity with an other series, that of aluminium (Al_2, Ga_2, Tn_2, Cr_2, Mn_2, Fe_2), but this nevertheless decidedly differs from the former by an other typical double sulphate,

$$K_2SO_4 + R_2 3SO_4 + 24H_2O.$$

or alum.

The fact, which has been alleged as a proof of the bivalence of beryllium, namely, that the chloride fuses and sublimes at a higher temperature than aluminium chloride is of no importance, for it will be found that amongst the members of the former series, with its difficultly fusible and volatilisable chlorides, many analogies exist for beryllium, not only in this but in many other respects.

Lastly, we subjoin a table showing the magnetic properties of the rare earths. Mr. Knut Ångström kindly undertook this research, employing a powerful electromagnet of Ruhmkorff, between the poles of which the oxides showed the following properties :—

Magnetic.		Diamagnetic.
Cr_2O_3	. . . .	Be_2O_3
Fe_2O_3	. . . .	Al_2O_3
Y_2O_3	. . . .	Sc_2O_3 ?
Di_2O_3	. . . .	In_2O_3
Er_2O_3	. . . .	La_2O_3
Yb_2O_3	. . . .	—
—	. . . .	ZrO_2
CeO_2	. . . .	ThO_2

III. "On the Absorption Spectra of Cobalt Salts." By W. J. RUSSELL, Ph.D., F.R.S., Treas. C.S., Lecturer on Chemistry at the Medical School, St. Bartholomew's Hospital. Received August 4, 1880.

(Abstract.)

The following investigation was commenced with Mr. Lockyer, and although he has been unable to continue the work, the author is indebted to him for much aid and many suggestions.

The cobalt salt first examined was the anhydrous chloride. In order to establish clearly its absorption spectrum, different samples of this salt were made by various processes. All, however, gave the same spectrum. The bromide of cobalt yields a similar spectrum, but its position is different, it is nearer to the red.

On fusing cobalt chloride with potassic chloride, a greenish-blue mass is formed, which gives a spectrum entirely different from that of the chloride when alone. Judging from the fusing-point of the mixture being lower than that of the components, and the cobalt salt not decomposing in this mixture on fusion in contact with air, it seemed natural to suppose that a new compound had been formed, and that it gave rise to the new spectrum. Further experiment showed, however, that this is not the case for other solid chlorides, such as of sodium and zinc give with cobalt chloride the same spectrum; and liquids in which the cobalt chloride easily dissolves, such as ordinary or amylic alcohol, the saline ethers, glycerine, and hydrochloric acid, also give this same spectrum; in fact, this spectrum is produced whenever cobalt chloride dissolves freely in any menstruum without definitely combining with it. A careful set of experiments were made in the case of the solid chlorides, to exclude the presence of water, for it was possible that the spectrum in all the above cases might be due to a trace of water, which, by its combining with the cobalt chloride, formed in every instance the spectrum-giving body.

The bromide and iodide of cobalt, when fused with potassium bromide and potassium iodide respectively, give results corresponding to those of the chloride, but the bands in the spectrum of the bromide, and still more so those of the iodide, are nearer to the red than the corresponding bands of the chloride. The action of heat and of water on the bodies producing these spectra is discussed, and it is pointed out how the definite compound with zinc was indicated by the spectrum. The action of liquids which easily dissolve the cobalt chloride is next described, and as all give the same spectrum, and this spectrum is identical with that obtained with the fused chlorides, the conclusion drawn is, as before stated, that this spectrum must be that of the cobalt chloride, only, owing to solution, it is in a molecular state, different from that obtained on fusing this salt alone. This spectrum, when obtained in the hydrochloric acid solution, is remarkable for its persistence under varying circumstances, and for its being a reaction of great delicacy.

Hydrochloric acid as a solvent for the cobalt chloride differs in one respect from all the other solvents which have as yet been examined, namely, that, whether much or little cobalt be dissolved in it, the spectrum is the same; whereas with dry alcohol, for instance, a saturated, or nearly saturated, solution gives the spectrum above mentioned, but a dilute solution, one containing about 20 grms. of the chloride in 100 cub. centims. of alcohol, gives a spectrum somewhat different: a new band appears and others which were present fade out: if this dilution be carried on still further, so that only about 0·008 grm. of the chloride be present in 100 cub. centims. of alcohol, an entirely different spectrum is obtained, but on carrying the dilution beyond this no

further change takes place. With other liquids which dissolve the cobalt salt freely, a similar series of changes occur, but if liquids in which the chloride is much less soluble be used, then according to their solvent power only the first (or most dilute stage), or the first and second stage, is obtainable; for instance, if dry ether is used as the solvent, it yields only a spectrum corresponding to the first stage. With anhydrous acetic acid, in which the cobalt chloride is more freely soluble, both the first and second stage are obtainable. If the dry chloride in fine powder be shaken up with a liquid in which it is insoluble, such as carbon tetrachloride, then only a spectrum similar to that of the fused chloride is visible.

The anhydrous cobalt chloride dissolved in water gives a pink solution. This solution, when it contains as little as 0·1 grm., or as much as 25 grms., of the salt in 100 cub. centims. of water, gives only a wide absorption-band, shading off on both sides, and whether a short column of the strong solution or a correspondingly long column of the dilute solution be examined, identical spectra are obtained, so that within these limits the same compound appears to exist in the solution. If, however, the solution approaches saturation (100 cub. centims. of water can dissolve at 16° 32 grms. of the cobalt chloride), then another spectrum is visible, and this is again the spectrum of the dissolved chloride : the same spectrum as is obtained either by dissolving cobalt chloride in fused potassium chloride, or in alcohol, or in hydrochloric acid, thus apparently the anhydrous chloride exists in an aqueous solution. The action of heat, and the action of bodies capable of combining with water, in aqueous solutions of cobalt chloride, are identical, both tending to destroy the broad absorption band of the hydrate, and to form the banded spectrum of the dissolved anhydrous chloride.

The very characteristic spectrum of the oxide of cobalt is well known. The precipitate obtained by the addition of potash or soda in excess to any cobaltous salt, shows well this spectrum. If ammonia be the precipitant, a somewhat simpler spectrum is obtained. Vogel has already pointed out the similarity of the spectrum of a piece of cobalt glass and this oxide spectrum. The glass spectrum is apparently similar to the spectrum formed by the precipitate with potash and soda, probably then the extra band visible in these cases and not when ammonia is used, is due to a compound of the alkali and cobalt. The bearing of these spectra on Winkler's supposed cobaltate of potash is then discussed. Further, it is shown that if the above precipitation of oxide be made in solutions in which the cobalt salt is in excess, or even if precipitated oxide be warmed or shaken up in the cold with a solution of cobalt chloride, a new compound is formed, an oxychloride which gives a different spectrum ; its formation and its decomposition by water is well traced in the varying spectra producible from it, and

goes hand in hand with the chemical changes which occur. From the spectroscopic appearance it is argued that the blue precipitated oxide is not a hydrate, but that it does very readily undergo change as the mere alteration of colour which takes place shows. Aqueous solutions of the bromide and iodide of cobalt when acted on by alkalies undergo changes similar to those which the chloride undergoes, and, as in the former cases, the iodide spectrum is always nearer the red end of the spectrum than the corresponding bromide spectrum, and the bromide than the chloride spectrum.

The salts of the oxygen acids when in aqueous solution do not give sharp banded spectra as the haloïd salts do, but only a large shading off absorption like the hydrate of the cobalt chloride.

The other points discussed in detail are, first, the nature of the precipitate formed by the action of sodic or potassic carbonate on a cobaltous salt, and it is shown that the formation of the oxide always found in this precipitate is owing to an after decomposition, the precipitate as first formed being entirely free from all oxide, and it gradually appearing after a short time. The other point is the action of heat on cobalt phosphate dissolved in fused microcosmic salt; when cold there appears somewhat indistinctly a banded spectrum of a phosphate, on heating this the spectrum disappears, and the spectrum of the oxide very distinctly takes it place ; on cooling, the first spectrum returns, and this change may apparently be repeated any number of times.

Drawings of all the different spectra are given in the full paper.

IV. "On the Friction of Water against Solid Surfaces of Different Degrees of Roughness." By Professor W. C. UNWIN, M.I.C.E., Professor of Hydraulic Engineering at the Royal Indian Engineering College. Communicated by J. H. COTTERILL, F.R.S., Professor of Applied Mechanics, Royal Naval College, Greenwich. Received August 31, 1880.

(Abstract.)

These experiments relate to the friction of fluids when flowing against rough solid surfaces. It is well known that a board dragged through water suffers a resistance which, at speeds not very small, varies nearly as the square of the velocity. The fluid surrounding the board does not behave as a solid, but shearing and eddying motions are set up which give rise to losses of energy distributed throughout the fluid mass.

Most of the existing knowledge of fluid friction has been derived from the observation of the flow of water in pipes and canals. But in